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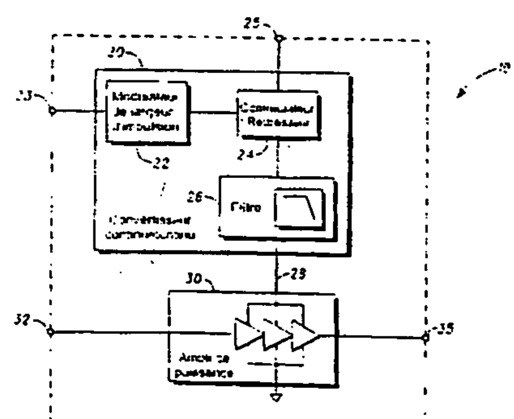
(54) CIRCUIT ET PROCEDE D'AMPLIFICATION DE PUISSANCE.

(57) Un circuit d'amplification de puissance comporte un amplificateur de puissance (30) comportant une entrée de signal (32), une sortie (35) et une entrée d'alimentation (28). Un convertisseur continu-continu (20) comportant une entrée de signal (21) est couplé pour appliquer une puissance sur l'entrée d'alimentation de l'amplificateur de puissance en fonction de l'entrée de signal du convertisseur continu-continu. L'entrée de signal de l'amplificateur de puissance est agencée pour se voir appliquer un signal prédéterminé, de telle sorte que la sortie de l'amplificateur de puissance soit saturée ou soit en sous-utilisation de puissance par rapport à la saturation conformément à une relation prédéterminée.



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varier le niveau du signal d'entrée afin de faire varier la puissance de sortie mais bien que davantage prédictible, cette technique est très inefficace.

Dans les systèmes qui utilisent des schémas de modulation complexes mettant en jeu à la fois une modulation en phase et en amplitude, l'efficacité de l'amplificateur de puissance ne peut pas être complètement optimisée du fait qu'il ne peut pas être saturé (il n'est pas possible de distordre le contenu MA (modulation d'amplitude).

Un procédé typique utilisé avec une modulation complexe consiste à faire fonctionner l'amplificateur de puissance à un nombre de décibels donné au-dessous de la saturation (ce fonctionnement est appelé sous-utilisation de puissance) et à utiliser des technologies de semiconducteur spécifiques qui permettent une efficacité satisfaisante avec la linéarité requise.

Cependant, ces technologies ne peuvent pas être aisément combinées avec d'autres composants du dispositif portable, et sont coûteuses. Certaines techniques ont été développées, telles qu'une élimination et une reconstitution d'enveloppe ou une contre-réaction cartésienne, mais ces techniques ajoutent de la complexité et utilisent des boucles de contre-réaction coûteuses qui souffrent des mêmes problèmes que ceux décrits ci-avant, c'est-à-dire de leur manque d'efficacité.

Il existe un besoin pour proposer un dispositif électronique amélioré qui présente une consommation d'énergie réduite par comparaison avec les dispositifs connus. La présente invention vise à proposer un circuit et un procédé d'alimentation qui atténuent les inconvénients mentionnés ci-avant.

Résumé de l'invention

Selon un premier aspect de la présente invention, on propose un circuit d'amplification de puissance pour amplifier un signal modulé comprenant : un amplificateur de puissance comportant une entrée de signal, une sortie de signal et une entrée d'alimentation ; et un convertisseur continu-continu comportant une entrée de signal couplée pour recevoir le signal modulé, et couplé pour appliquer une puissance sur l'entrée d'alimentation de l'amplificateur de puissance en fonction du signal sur l'entrée de signal du convertisseur continu-continu, dans lequel l'entrée de signal de l'amplificateur

l'amplificateur de puissance est de préférence déterminé en fonction de la puissance requise pour émettre un signal depuis le dispositif de télécommunication portable vers une station de base.

De préférence, la puissance requise pour émettre le signal est déterminée à partir d'un signal envoyé depuis la station de base vers le dispositif électronique portable. De préférence, la puissance requise pour émettre le signal est déterminée à partir d'une mesure des erreurs de transmission associées à des signaux envoyés entre la station de base et le dispositif électronique portable.

De cette façon, un circuit et un procédé d'amplification de puissance sont proposés, lesquels fonctionnent avec une efficacité élevée sur une plage de niveaux de puissance et/ou de schémas de modulation, de telle sorte que l'énergie dans un dispositif de télécommunication portable puisse être économisée.

<u>Brève description des dessins</u>

Un mode de réalisation typique de l'invention est maintenant décrit par report aux dessins parmi lesquels :

la figure 1 représente un mode de réalisation préféré d'un circuit d'alimentation selon l'invention ;

les figures 2 et 3 représentent des diagrammes de cadencement de signaux d'entrée et de sortie associés à un premier mode de fonctionnement du circuit de la figure 1 ; et

les figures 4 et 5 représentent des schémas de cadencement de signaux d'entrée et de sortie associés à un second mode de fonctionnement du circuit de la figure 1.

<u>Description détaillée d'un mode de réalisation préféré</u>

Sur la figure 1 est représenté un circuit d'amplification de puissance 10 qui convient pour une utilisation dans un dispositif de télécommunication portable tel qu'un téléphone mobile. Le circuit d'amplification de puissance comprend un convertisseur continu-continu 20 et un amplificateur de puissance 30. Le convertisseur continu-continu 20 comprend un modulateur

Le signal de sortie filtré 28 du convertisseur continu-continu 20 est déterminé seulement par le signal modulé en largeur d'impulsion reçu au niveau de l'entrée de signal 21. Lorsque ce convertisseur est connecté à une charge résistive constante (et qu'un amplificateur de puissance en saturation représente une telle charge), la fonction de transfert du convertisseur continu-continu 20 (sortie continue V_{DCt} en fonction de la tension d'entrée de commande V_{CTL}) est également linéaire et prédictible, et est donnée par :

$$V_{DCt} = k'''*V_{CTL} \qquad \text{Equation 3}$$

A partir des équations 2 et 3, il peut être démontré que la fonction de transfert du circuit d'amplification de puissance 10 (amplitude de sortie saturée en fonction de la tension de commande) est linéaire et prédictible :

$$V_{RF\ Sat} = k*V_{CTL} \qquad \text{Equation 4}$$

Par conséquent, la saturation de puissance de sortie est donnée par :

$$P_{RF\ Sat} = k'*V_{DC}^{2} \qquad \text{Equation 5}$$

De cette façon, la capacité de puissance ou de tension saturée du circuit d'amplification de puissance 10 peut être obtenue dans un mode "boucle ouverte" sans la nécessité d'un agencement de contre-réaction qui inclurait la détection et la mesure du signal de sortie de l'amplificateur de puissance 30.

En outre, lorsque la condition de saturation est satisfaite, l'efficacité de l'amplificateur de puissance saturé 30, soit n_{PA}, est le maximum possible, et est maintenue pratiquement constante sur toute une plage importante du signal d'entrée d'alimentation (par exemple 50 à 60% pour plus d'une décade). Par conséquent, l'efficacité totale est donnée par :

$$n_T = n_{PA}*n_{DC} \qquad \text{Equation 6}$$

La mise en forme de rafale consiste à contrôler le front montant et le front descendant d'une rafale de signal afin de garantir simultanément une vitesse donnée ou une puissance donnée en fonction d'un masque temporel et d'un masque spectral donné qui assure des interférences spectrales dues à un canal voisin faibles .

La puissance de sortie nominale est fixée en fonction de la distance entre le dispositif portable dans lequel le circuit d'amplification de puissance 10 est utilisé, et une station de base avec laquelle il est en train de communiquer, de manière à empêcher l'émission d'une puissance excessive lorsque le dispositif est proche de la station de base. Le bénéfice de cette commande de puissance adaptative consiste à réduire le niveau d'interférence et à abaisser la consommation d'énergie globale du dispositif portable.

Sur la figure 3 est représenté un diagramme temporel du même agencement, avec un signal modulé en amplitude 150. Dans ce cas, le signal d'entrée de commande continu-continu modulé en amplitude définit l'enveloppe 175 du signal de tension de sortie 170 de l'amplificateur de puissance 30. Le signal d'entrée 160 de l'amplificateur de puissance est sensiblement d'une amplitude constante, et maintient le signal de sortie en saturation, et peut être modulé en phase ou en fréquence. Un signal modulé en amplitude est typique pour des systèmes de télécommunication à accès multiple à répartition dans le temps (AMRT) ou à accès multiple par différence de code (AMDC) avec une modulation par déplacement de phase en quadrature (MDPQ) tels que le système de télécommunication cellulaire numérique du Pacifique PDC (Pacific Digital Cellular) et le système de télécommunication cellulaire numérique d'Amérique du Nord NADC (North American Digital Cellular). L'efficacité totale reste à un très bon niveau indépendamment de la modulation d'amplitude.

Selon un second agencement du circuit d'amplification de puissance 10, la sortie de l'amplificateur de puissance 30 est en sous-utilisation de puissance par rapport à (est à un niveau de décibels prédéterminé inférieur à) la saturation de la sortie, tel que 3 dB au-dessous du point de saturation. Ceci est réalisé du fait que dans certains cas, le fait de disposer d'une sortie

REVENDICATIONS

1. Circuit d'amplification de puissance (10) pour amplifier un signal modulé, comprenant un amplificateur de puissance (30) comportant une entrée de signal (32), une sortie de signal (35) et une entrée d'alimentation (28), caractérisé en ce qu'il comprend

un convertisseur continu-continu (20) comportant une entrée de signal (21) couplée pour recevoir le signal modulé, et couplé pour appliquer une puissance sur l'entrée d'alimentation de l'amplificateur de puissance en fonction du signal modulé reçu,

l'entrée de signal de l'amplificateur de puissance étant agencée pour se voir appliquer un signal de saturation de telle sorte que la sortie de l'amplificateur de puissance soit saturée.

2. Circuit d'amplification de puissance (10) pour amplifier un signal modulé, comprenant un amplificateur de puissance (30) comportant une entrée de signal (32), une sortie de signal (35) et une entrée d'alimentation (28), caractérisé en ce qu'il comprend

un convertisseur continu-continu (20) comportant une entrée de signal (21) couplée pour recevoir le signal modulé, et couplé pour appliquer une puissance sur l'entrée d'alimentation de l'amplificateur de puissance en fonction du signal modulé reçu,

l'entrée de l'amplificateur de puissance étant agencée pour se voir appliquer un signal tel que le signal de sortie de l'amplificateur de puissance présente une relation prédéterminée avec le point de saturation de l'amplificateur de puissance.

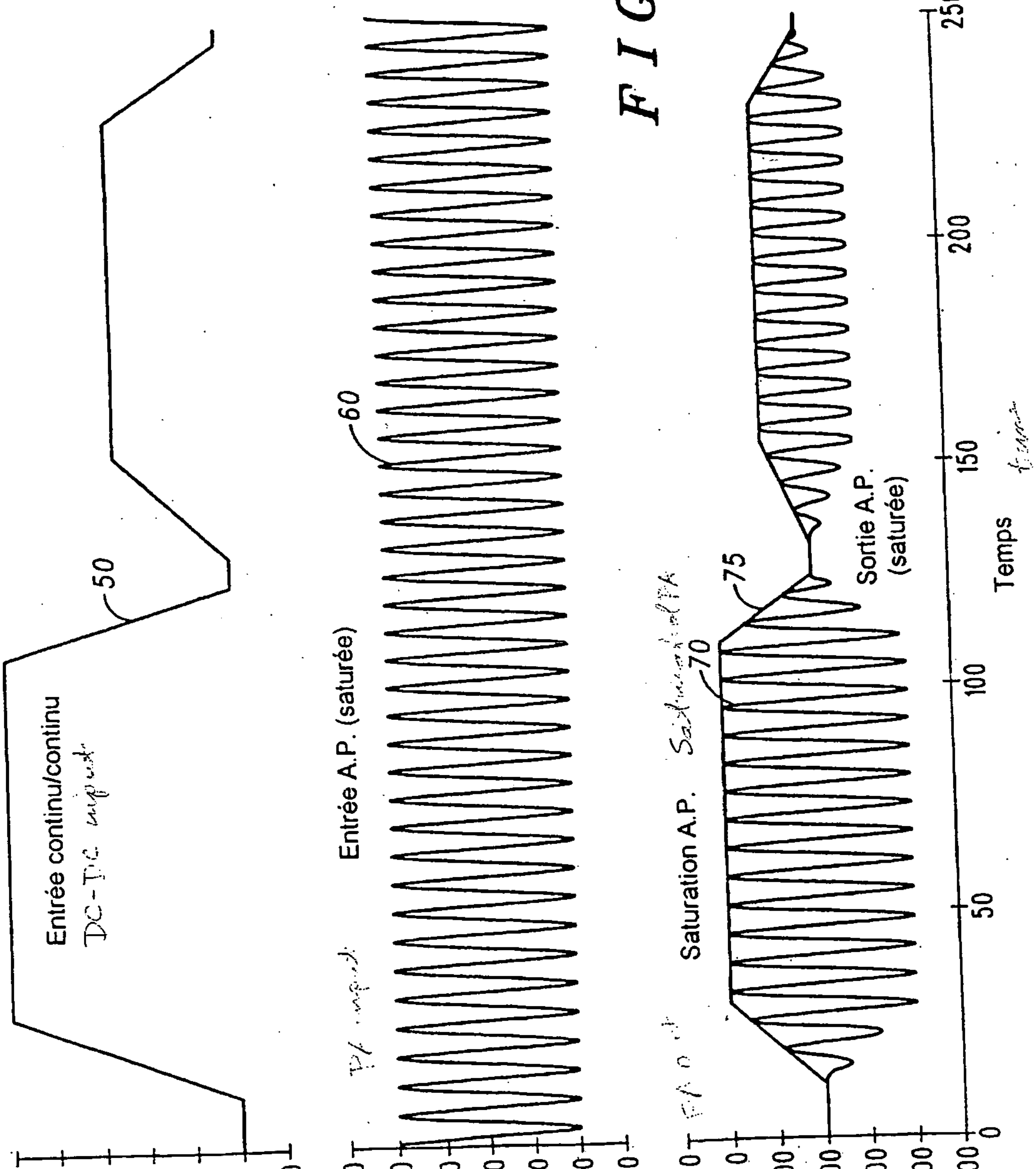
3. Circuit d'amplification de puissance selon la revendication 1 ou 2, caractérisé en ce que le signal modulé est modulé en phase et en amplitude, une information de phase étant utilisée pour dériver le signal sur l'entrée de l'amplificateur de puissance (30), et une information d'amplitude provenant du signal modulé étant utilisée pour dériver le signal sur l'entrée de signal (21) du convertisseur continu-continu (20).

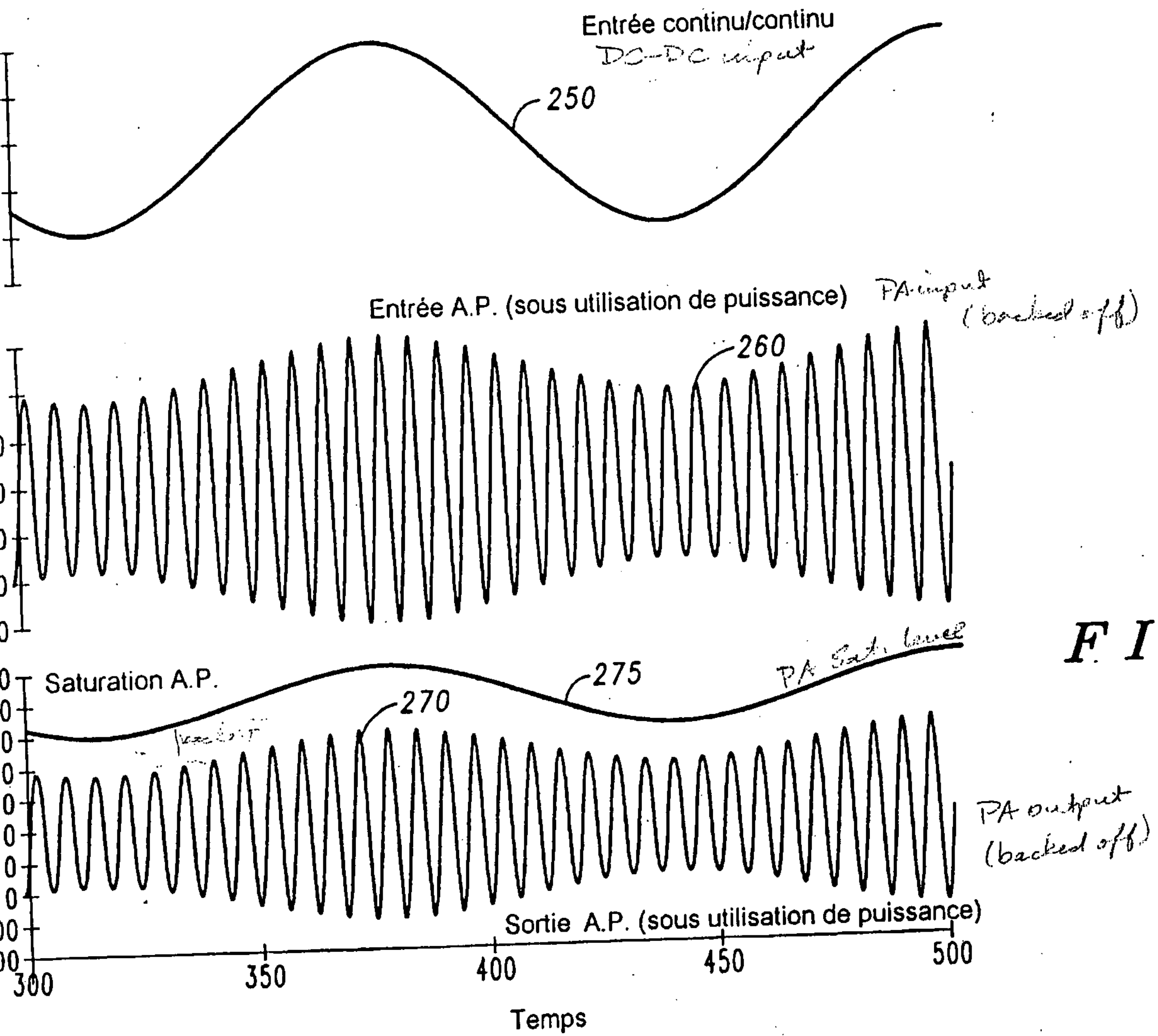
8. Procédé d'amplification selon la revendication 6 ou 7, caractérisé en ce que le signal modulé est modulé en phase et en amplitude, une information de phase étant utilisée pour dériver le signal sur l'entrée de l'amplificateur de puissance (30), et une information d'amplitude provenant du signal modulé étant utilisée pour dériver le signal sur l'entrée de signal (21) du convertisseur continu-continu (20).

9. Procédé d'amplification selon la revendication 7, caractérisé en ce que la relation prédéterminée est sensiblement un niveau de décibels constant au-dessous de la saturation.

10. Procédé d'amplification selon l'une quelconque des revendications 6 à 9, caractérisé en ce que l'amplificateur de puissance (30) est incorporé dans un dispositif de télécommunication portable, et en ce que le signal de sortie de l'amplificateur de puissance est déterminé en fonction de la puissance requise pour transmettre un signal depuis le dispositif de télécommunication portable vers une station de base.

FIG. 2


Entrée continu/continu
DC-DC input
50
Entrée A.P. (saturée)
60
Saturation A.P.
70
75
Sortie A.P.
(saturée)
0
50
100
150
200
250
Temps



Entrée continu/continu
DC-DC input
250
Entrée A.P. (sous utilisation de puissance)
PA input (backed off)
260
Saturation A.P.
275
PA Sat. level
270
PA output (backed off)
Sortie A.P. (sous utilisation de puissance)
300
350
400
450
500
Temps

FIG. 4

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RAPPORT DE RECHERCHE
PRELIMINAIRE

établi sur la base des dernières revendications
déposées avant le commencement de la recherche

N° d'enregistrement national

FA 551116
FR 9711432

DOCUMENTS CONSIDERES COMME PERTINENTS		Revendications concernées de la demande examinée	
Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes		
X	NOJIMA T ET AL: "CIRCUIT TECHNOLOGY FOR MOBILE/PERSONAL COMMUNICATIONS" 24TH. EUROPEAN MICROWAVE CONFERENCE PROCEEDINGS, CANNES, SEPT. 5 - 8, 1994, vol. VOL. 1, no. CONF. 24, 5 septembre 1994, EUROPEAN MICROWAVE MANAGEMENT COMMITTEE, pages 220-229, XP000643169 * page 221 - page 224; figure 4 * ---	1-10	TK 7876 E87
A	GB 1 184 968 A (COLLINS RADIO COMPANY) 18 mars 1970 * page 3, ligne 52 - page 5, ligne 7; figures 1-3 * ---	1-4,6-9	
A	KOHJI CHIBA ET AL: "LINEARIZED SATURATION AMPLIFIER" COMMUNICATIONS: CONNECTING THE FUTURE, SAN DIEGO, DEC. 2 - 5, 1990, vol. VOL. 3, no. -, 2 décembre 1990, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 1958-1962, XP000218908 * le document en entier * -----	1-10	DOMAINES TECHNIQUES RECHERCHES (Int.CL.6) H03F

1	Date d'achèvement de la recherche	Examinateur
	20 mai 1998	Tyberghien, G

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(56) List of documents mentioned in the preliminary search report:
See at the end of this notice

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(74) Agent: Offices of Beau de LOMENIE

(54) Power Amplifier Circuitry and Technique

(57) A power amplifier circuitry comprising a power amplifier (30), a signal input (32), an output (35) and a power supply input (28). A dc-to-dc converter (20) with signal input (21) is coupled to apply current to the power amplifier power supply as a function of the dc-to-dc converter input signal. The power amplifier input signal is constructed to have a predetermined signal applied to it so that the power amplifier output signal is saturated or is under-utilizing power as compared to saturation, in accordance with a pre-determined relationship.

Figure: *see Figure 1 at end of document*

Invention Domain

This invention relates to power amplifier circuits such as those used in portable communication radio devices.

Invention Background

A key goal of the design of new portable electronic devices is to reduce the energy consumption of the device. In portable electronic devices, the battery endurance c an be increased, and thus the talk time or the stand-by time can be increased through a reduction of energy consumption. Many ideas have been developed to achieve this purpose.

A power amplifier is used in cellular radio communication devices to produce radio-frequency (RF) energy in order to transmit signals. In the past, such a power amplifier was always optimized in terms of efficiency for a full power status.

Given the increase of the base cellular station numbers and the improvement of portable device transmission spectrums, it is no longer necessary to have the power amplifier always operate at full power. Therefore, this provides an opportunity to reduce energy consumption by operating the power amplifier at a reduced power level when near a base station.

However, a problem with this arrangement stems from the fact that it is difficult to design a power amplifier which is efficient, from an energy viewpoint, over a whole range of output power levels — particularly with a power amplifier having a controlled output power by varying a polarization current, in which a non-linear and non-predictable behavior of the output signal requires a closed-loop control arrangement. In a closed-loop, the output power is detected and applied as a feedback to ensure the control of the amplifier. This is costly, unstable, and hard to manufacture and operate.

It is also possible to vary the input signal level so as to vary the output power, but although this technique is more predictable, it is very inefficient.

In systems utilizing complex modulations using both amplitude and phase modulation, the power amplifier efficiency cannot be fully optimized because it cannot be saturated (it is impossible to distort the amplitude modulation (MA) content).

A typical process used with a complex modulation operates the power amplifier at a given number of decibels below saturation (this operation is called power under-utilization) an in using specific semiconductor technologies allowing a satisfactory efficiency with the required linear quality.

However these technologies cannot be easily combined with other components of the portable device and they are expensive. Certain other techniques were also developed, such as an envelope elimination and reconstitution, or a Cartesian counter-reaction, but these techniques add complexity and use expensive counter-reaction loops which suffer from the same problems as those described above, that is to say they lack of efficiency.

There is therefore a need to design an improved electronic device offering reduced energy consumption when compared with known devices. This invention aims at proposing a circuit and power supply process which will mitigate the above-mentioned inconvenient.

Summary of the Invention

The first aspect of this invention proposes a power amplifier circuit to amplify a modulated signal comprising: a power amplifier with an input signal, a signal output and a power supply input; as well as a dc-to-dc converter with a coupled signal input to receive the modulated signal, and coupled to apply power to the power amplifier power supply as a function of the signal of the dc-to-dc converter input signal, in which the power amplifier signal input is arranged so as to have a signal applied to it in such a way that the power amplifier output is saturated.

A second aspect of this invention proposes a power amplifier operating process comprising an input, an output and a power supply input, wherein this process includes the following steps: power application to the power amplifier power supply input, utilizing a dc-to-dc converter as a function of the signal of the dc-to-dc converter input signal, and application of a signal to the power amplifier input so that the power amplifier output is saturated.

A third aspect of this invention proposes a power amplifier circuit comprising: a power amplifier with an input signal, a signal output and a power supply input; and a dc-to-dc converter with a signal input, and coupled to apply power to the power amplifier power supply as a function of the signal of the dc-to-dc converter input signal, in which the power amplifier signal input is arranged so as to have a signal applied so that the power amplifier output offers a pre-determined relationship to the power amplifier saturation point.

A fourth aspect of this invention proposes a power amplifier operating process comprising an input, an output and a power supply input, wherein this process consists of the following steps: power application to the power amplifier power supply input, utilizing a dc-to-dc converter as a function of the signal of the dc-to-dc converter input signal, and application of a signal to the power amplifier input such that the power amplifier output signal offers a pre-determined relationship to the power amplifier saturation point.

The modulated signal is preferably modulated in phase and in amplitude, with phase information used to shift the signal to the power amplifier input, and amplitude information from the modulated signal used to shift the signal to the dc-to-dc converter input signal. Preferably, the predetermined relationship is roughly a constant decibel level below saturation.

The power amplifier is preferably incorporated into a portable telecommunication device,

and the output signal of the power amplifier is preferably determined as a function of the power required to send a signal from the portable telecommunication device to a base station.

Preferably, the power required to send the signal is determined from a signal sent out from the base station to the portable telecommunication device. It is also preferable when the power required to send the signal is determined by a measurement of transmission errors connected with signals sent between the base station and the portable telecommunication device.

In this manner, a circuit and a power amplification process are proposed which operate with high efficiency over a range of power levels and/or of modulation designs so that the energy in a portable telecommunication device can be economized.

Brief description of the drawings

A typical construction method is now described as pertains to the drawings, among which:

Figure 1 represents a preferred construction method for a power supply circuit per the invention;

Figures 2 and 3 show rate diagrams of input and output signals associated with a first operating mode of the circuit in Figure 1; and

Figures 4 and 5 show a graph of the rate input and output signals associated with a second operating mode of the circuit in Figure 1.

Detailed description of a preferred construction method

Figure 1 shows a power amplifier circuit 10 suitable for use in a portable telecommunication device such as a mobile telephone. The power amplifier circuit comprises a dc-to-dc converter 20 and a power amplifier 30. The dc-to-dc converter 20 includes an impulse-width modulator 22, a commutator/rectifier 24 and a filter 26.

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The impulse-width modulator 22 is coupled to receive a dc-to-dc command input signal from a signal input terminal 21, and it is arranged to apply an input-width modulated signal on the commutator/rectifier 24. The commutator/rectifier 24 is also coupled to receive a dc-to-dc power supply input signal from a signal input terminal 25, and it is also coupled to apply a switched signal on filter 26, which in turn applies a filtered switched signal 28 on power amplifier 30.

The power amplifier 30 comprises an input signal 32 which will be further described later on, a power supply input 28 coupled to receive the filtered switched signal from filter 26 on the dc-to-dc converter 20 and an output signal 35.

In previous designs, the signal input and/or a (bias) polarization current from power amplifier 30 was modified to produce a variation of level at output 35 of power amplifier 30. The power supply input of power amplifier 30 provides a relatively constant current over the entire operating range. However, in the power supply circuit 10, the power supply input to power amplifier 30 receives the filtered switched signal 28, and this signal varies as a function of the dc-to-dc command input signal from the dc-to-dc converter 20.

The output power saturation of power amplifier 30 is determined solely by its power supply voltage. The transfer function of power amplifier 30 (saturated output amplitude $V_{RF\,Sat}$ as a function of the input power supply voltage V_{DC}) is linear and predictable, in accordance with the following equation:

Equation 1

$$V_{RF\,Sat} = k' V_{DC}$$

Consequently, when the output load line R_L is constant, which is the usual case with RF power amplifiers, the output power output will be determined by:

Equation 2

$$P_{RF}Sat = k'' \left(V_{DC}^2 / (2^* R_L)\right)$$

The filtered output signal 28 from the dc-to-dc converter 20 is determined only by the impulse-width modulated signal received at the input signal 21. When this converter is connected to a constant resistive load (and a saturated power amplifier represents such a load), the transfer function of the dc-to-dc converter 20 (dc output V_{DC1} as a function of the command input voltage V_{CTL}) is also linear and predictable, and is determined by:

$$V_{DC1} = K''' V_{CTL} \qquad \text{Equation 3}$$

load = R_L = constant

From equations 2 and 3 it can be shown that the transfer function of the power amplifier circuit 10 (saturated output amplitude as a function of command voltage) is linear and predictable:

$$V^{RF}\,Sat = K^{*}V_{CTL} \qquad \text{Equation 4}$$

Consequently the output power saturation is determined by:

$$P_{RF}\,Sat = k'{*}V_{DC}^{2} \qquad \text{Equation 5}$$

In this manner, the power or voltage saturated capacity of the power amplifier circuit 10 can be achieved in an open-loop mode without having to resort to a counter-reaction, which would include detection and measurement of the output signal of power amplifier 30. feedback loop

Furthermore, when the saturation condition is satisfied, the efficiency of power amplifier 30, or n_{PA}, is the maximum possible, and is kept practically constant over an important range of the power supply input signal (for instance 50 to 60% for an entire decade). Consequently, the total efficiency is determined by:

$$nT = nPA^{*}nDC \qquad \text{Equation 6}$$

where nDC is the efficiency of the dc-to-dc converter 20.

Provided that n_{DC} is maintained at an optimum value over the same range as power amplifier 30 (for instance 80 to 90%), the system efficiency n_T is kept at a very high level over a large dynamic range.

This also constitutes a very efficient and predictable means for controlling the output signal amplitude when amplitude modulation is desired in the output signal (the power amplifier input signal can be modulated in phase or frequency). This simplifies the counter-reaction (feedback loop) requirements mandated in envelope elimination and reconstitution techniques, and at the same time ensures a higher efficiency.

The power amplification circuit 10 can operate in two ways, as a function of the signal applied to the input signal of power amplifier 30. In a first arrangement, a signal with a relatively constant amplitude is applied to the input signal of power amplifier 30, so that the output of power amplifier 30 remains always saturated. This can be simply achieved by choosing a high input signal in some appropriate fashion. The signal applied to the input signal of power amplifier 30 can be modulated in phase or frequency.

Figure 2 shows a time diagram of the first arrangement mentioned above, when a burst signal 50 is present at the command input to the dc-to-dc converter 20. A burst signal is typical in telecommunication systems with multiple accesses over time (MAOT) with constant amplitude modulation (phase or frequency modulation only) such as in the GSM900, DCS1800, DCS1900 systems, or the Digital European Cellular Telecommunication (DECT) system. The burst signal 50 determines the envelope 75 of the output signal 70, per Equation (5) previously shown. The power amplifier input signal 60 has a constant amplitude, it maintains the output signal in a saturated mode and it can be modulated in phase or frequency. As shown in the figure, the power amplification circuit 10 achieves both the shaping of the burst and setting of the nominal output power, while maintaining its efficiency, regardless of output power.

(In principle...)

Real Effects:

1. $f_{PWM} >> \frac{1}{t_r}, \frac{1}{t_f}$
2. SMPS needs control loop to handle I load dynamic range
3. SMPS control loop BW $>> \frac{1}{t_r}, \frac{1}{t_f}$ and $< f_{PWM}$
4. $P_{out} \neq 0$ when $V_{supply} = 0$
5. Signal phase can change rapidly with varying supply level (esp. for low [illegible])

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The shaping of the burst is based on controlling the rise and fall of a signal burst in order to guarantee simultaneously a given velocity or a given power as a function of a temporal mask and a given spectral mask, which ensure weak spectral interferences due to a neighboring channel.

The rated output power is established as a function of the distance between the portable device in which the power amplification circuit 10 is used, and a base station with which it is communicating, in order to prevent transmitting excessive power when the device is close to the base station. The advantage of this adaptive power control is a reduction of the interference level and a decrease of the overall energy consumption of the portable device.

Figure 3 shows a time diagram of the same arrangement with an amplitude modulated signal 150. In this case, the amplitude-modulated dc-to-dc input control signal defines the envelope 175 of the output signal voltage 170 of power amplifier 30. The power amplifier input signal 160 is relatively constant in amplitude, it maintains the saturation of the output signal, and can be modulated in phase or frequency. An amplitude modulated signal is typical for telecommunication systems enabling multiple access over time (MAOT) or multiple access by code differentiation (MACD) with modulation by quadratic phase displacement (MQPD) such as the Pacific Digital Cellular (PDC) system and the North American Digital Cellular (NADC) system. The overall efficiency remains at a very good level regardless of amplitude modulation.

In a second arrangement of the power amplification circuit 10, the output of power amplifier 30 reflects under-utilization of power relative to the output saturation (and is at a predetermined decibel level less than this), such as 3 dB below the saturation point. This occurs because in certain cases the availability of a saturated power amplifier output may create interference and channel distortion. Sat PA is not always [illegible]?!

Further reality –

low for NADC

① $f_{PWM} >> f_{BW,SMPS} >> f_{AM,max}$

Consequently, in order to maintain efficiency while achieving a given linear quality (i.e. while limiting adjacent channel interferences and/or channel distortion generated by the non-linear quality of power amplifier 10), power under-utilization is employed instead of saturation. backoff

Figure 4 shows an example of power under-utilization. The output signal envelope 270 is set up to be at a certain level of decibels lower than the saturation point 275 (3 dB power under-utilization). The saturation point 275 is determined by the dc-to-dc command input signal 250, and the under-utilization value is determined via a predetermined variation of the power amplifier input envelope 260. In this way, a good efficiency can be achieved with good linear quality. The power amplifier input signal 260 can be modulated in phase or frequency. ½ power; 70% volts

The power under-utilization of the power amplification circuit 10 can be dynamically modified by using a predetermined signal (or a calculated signal based on the amplitude and/or phase properties of the modulated signal), so that the RF signal envelope can be followed by the power amplifier saturation. (limit set by V_{PA})

Figure 5 shows another example of power under-utilization, with an RF input signal having a non-constant envelope (for instance with a modulation by quadratic phase displacement (MQPD)). In this example, the burst signal 350 defines the envelope 375 for the power amplifier 30 saturation. The power amplifier 30 input signal is modulated in phase and amplitude, hence the creation of a complex signal 360. In this fashion, the power amplifier 30 output under-utilizes power by a non-constant value, while still achieving the required average output power. This arrangement achieves a power level adjustment with an adapted saturation capacity, along with a minimum guaranteed power under-utilization. In this case, the signal envelope is not followed, but the saturation capacity follows the average power adjustment, ~~maintaining~~ efficiency. (OM)
improving, assuming the bias [illegible]

It should be also noted that other construction modes than the one described above are possible.

Even more reality

(7) P_{sat} details vary with V_{PA} – a fixed offset is not necessarily desirable

(8) PA bias often varies under this operating mode [illegible] the [illegible] equations

(9) Without proven bias stability, thermal instability is [illegible]

CLAIMS

1. Power amplifier circuit (10) to amplify a modulated circuit, comprising a power amplifier (30) having a signal input (32), a signal output (35) and a power supply input (28), characterized by the fact that it includes

a dc-to-dc converter (20) with a signal input (21) coupled to receive the modulated signal, and coupled to apply power on the power supply input to the power amplifier, as a function of the modulated signal received,

wherein the power amplifier signal input is arranged so as to have a saturation signal applied to it so that the power amplifier output is saturated.

2. The power amplifier circuit (10) to amplify a modulated circuit, comprising a power amplifier (30) having a signal input (32), a signal output (35) and a power supply input (28), characterized by its including

a dc-to-dc converter (20) with a signal input (21) coupled to receive the modulated signal, and coupled to apply power on the power supply input to the power amplifier, as a function of the modulated signal received,

the power amplifier signal input being arranged so as to have a signal applied to it such that the power amplifier output presents a predetermined relation to the power amplifier saturation point.

3. The power amplifier circuit according to claim 1 or 2, characterized in that the modulated signal is modulated in phase and in amplitude, with phase information used to shift the signal on the input signal of the power amplifier (30), and amplitude information coming from the modulated signal used to shift the signal on the input signal (21) of the dc-to-dc converter (20).

4. The power amplifier circuit according to claim 2, characterized in that the pre-determined relationship is roughly a constant decibel level below saturation.

5. The power amplifier circuit according to any one of claims 1 to 4, characterized in that the power amplifier (30) is incorporated into a portable telecommunication device, and in that the power amplifier output signal is determined as a function of the power required to transmit a signal from the portable telecommunication device to a base station.

6. An amplification process for a modulated signal in a power amplifier (30) having an input (32), an output (35) and a power supply input (28), the process being characterized by its including steps for:

applying power to the power supply input to the power amplifier, using a dc-to-dc converter (20) as a function of the modulated signal; and

applying a saturation signal to the power amplifier input such that the power amplifier output be saturated.

7. An amplification process for a modulated signal in a power amplifier (30) having an input (32), an output (35) and a power supply input (28), the process being characterized by its including steps for:

applying power to the power supply input to the power amplifier, using a dc-to-dc converter (20) as a function of the modulated signal; and

applying a signal to the power amplifier input such that the power amplifier output presents a pre-determined relationship to the power amplifier saturation point.

8. The power amplifier process according to claim 6 or 7, characterized in that the modulated signal is modulated in phase and in amplitude, with phase information used to shift the signal on the input signal of the power amplifier (30), and amplitude information coming from the modulated signal used to shift the signal on the input signal (21) of the dc-to-dc converter (20).

9. The power amplifier process according to claim 7, characterized in that the pre-determined relationship is roughly a constant decibel level below saturation.

10. The power amplifier process according to any one of claims 6 to 9, characterized in that the power amplifier (30) is incorporated into a portable telecommunication device, and the power amplifier output signal is determined as a function of the power required to transmit a signal from the portable telecommunication device to a base station.

See Figure 1 through Figure 5

Figure 2

Left scales, top to bottom:

dc-to-dc input

Power amplifier input

Power amplifier output, V_{sat} P.A.

Graph callouts:

50 dc-to-dc input

60 Power amplifier input (saturated)

75 Power amplifier saturation

70 Power amplifier output (saturated

temps = time

Figure 3

Left scales, top to bottom:

dc-to-dc input

Power amplifier input

Power amplifier output, V_{sat} P.A.

Graph callouts:

150 dc-to-dc input

160 Power amplifier input (saturated)

175 Power amplifier saturation

170 Power amplifier output (saturated)

temps = time

Figure 4

Left scales, top to bottom:

dc-to-dc input

Power amplifier input

Power amplifier output, V_{sat} P.A.

Graph callouts:

250 dc-to-dc input

260 Power amplifier input (power under-utilisation)

275 Power amplifier saturation

270 Power amplifier output (power under-utilisation)

temps = time

Figure 5

Left scales, top to bottom:

dc-to-dc input

Power amplifier input

Power amplifier output, V_{sat} P.A.

Graph callouts:

350 dc-to-dc input

375 Power amplifier saturation

370 Power amplifier output (power under-utilisation)

temps = time

Figure 1

22 Pulse width modulator
24 Commutator/rectifier
26 Filter
20 dc-to-dc converter
30 Power amplifier

(last page):

PRELIMINARY RESEARCH REPORT

French Republic

National Institute
For Industrial Property

National Registration No. 2768574

Established on the basis of last claims FA 551116
Filed before the beginning of the research FR 9711432

DOCUMENTS CONSIDERED RELEVANT		Claims regarding examined application
Category	Cited document with and indication of relevant parties when required	Technic domain researched (Int. Cl. 6)
X	[the text is in English, "ligne" = line]	1-10
A		1-4, 6-9
A		1-10
Date when the research report was completed:	May 20, 1998	Examiner: Tyberghien, G

CATEGORIES OF CITED DOCUMENTS

X: particularly relevant to the document in question

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T: the theory or principle on which the invention is based

E: a patent document dated prior to the filing of the patent which was not published until the filing

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